PATENT SPECIFICATION

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(54) SPATIAL SIMULATOR FOR MARITIME, TACTICAL NAVIGATION WITH IN SIGHT SHIPS AND COASTLINES

(71) I, RENE HERVIEU of French Nationality of 20 Rue du Calvaire, 44000 Nantes, France, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed to be described in and by the following Statement:—

The present invention relates to a navigation simulator. More particularly it relates to an apparatus reproducing the picture, on a cylindrical screen, of moving floating devices, or coastlines. Said picture, on a level with an observer and covering 360° of the sky-line, is the same as that seen from the bridge of a supposed moving ship N.

It is well known to have the relative movements of movable model ships, on a table representing the sea, reproduced by camera and screens. The models and the optical transmission means required are cumbersome. This solution gives only a very vague semblance of the movements, on a level with the sky-line or close to the observer. It is difficult to simulate entering a harbour.

It is also known to project shadows onto a cylindrical screen, the shadows being obtained from a central projector and screens constituted by models. The models are planar and are shaped according to the outline of a coastline, or a ship, or a floating object. They are movable around the light-source and may be withdrawn from it, but they always remain parallel to the screen. Among the disadvantages of this system, there may be listed:— insufficient approach of the in-sight coastline or floating object; the projected image is too schematic; impossibility to correctly simulate the autonomous movement of the in-sight ship (particularly when rotating on its own axis), difficulties in projecting several in-sight ships simultaneously in the same zone.

The apparatus in accordance with the invention permits the above-mentioned disadvantages to be avoided.

On the screen around himself, the observer may see several ships manoeuvring on their own trajectories, and even passing round him. He may move about a moving or stationary floating object, and come within a minimal distance of it.

The same applies with an island or a part of a coastline. The apparatus also permits currents, waves, and wind effects to be simulated. It may also simulate rolling and pitching of a vessel. The simulation of a sea trip is complete. The pilot's initiatives (helm, ship's velocity) are exactly followed.

Other features will appear from the following description. They are all mainly obtained thanks to a projection system controlled by a special gears succession. Said projection is made from specially recorded and set out transparencies. It is made on a known cylindrical screen, in a lit room. Some embodiments of the invention are hereinafter particularly described with reference to the accompanying drawings, wherein:— The sketches (Figs. 1—3) giving the meaning of the symbols used, and the drawings illustrating the specification comprise:

Figure 1 is a plan view of the relative position of ships N and $N1$. N is the bearing ship, $N1$ is the observed ship, Nv—Sv is the true North-South line coincident with axis OY; T is the trajectory of ship N, V is its instantaneous speed; $T1$ is the true trajectory of ship $N1$ and $V1$ is its instantaneous speed; Ta is the apparent trajectory of ship $N1$ seen from ship N, and $V'1$ is its relative speed in relation to ship N (obtained by compounding the vectors $V1$ and V by a known method) θ, is counted starting from OY, and ρ is counted starting from N coincident with O.

Figure 2 is a sketch providing a definition of the following values: Gi: bearing from ship $N1$ with regard to ship N ($Gi = \theta - Cv$); Cv: the true course for ship N; $I1$: inclination of ship $N1$ for the observer standing at ship N ($I1 = Cv1 - \theta$); Cv1: the true course for ship $N1$.

Figure 3 is a sketch of positions of ship N in relation to an islet or peninsula L, serving

as a substitute for ship $N1$. Islet or peninsula L has no course.

Figure 4 shows a projector placed above the bridge of the bearing ship N seen in elevation at the centre of the cylindrical screen, and showing the connections of the projector to a computer.

Figure 5 is a section, along line AA on Fig. 4, of a disc bearing transparencies.

Figure 6 shows the disc with its rotation mechanism (section along line B on Fig. 10).

Figure 7 shows transparencies on a disc, and Figure 8 shows a modified embodiment of transparencies on a disc.

Figure 9 shows a mechanism for correcting the angle of projection in relation to the distance $NN1$.

Figure 10 is a half-section through the axis of the disc support.

Figure 11 is a detail seen in section on line C in fig. 10 of the driving means of the disc.

Figure 12 shows a variant of the mounting and animation device for the transparencies, seen in front elevation.

Figure 13 is a plan view of the above-mentioned modification, with a belt.

Figure 14 is a detail, seen in front elevation, of the belt carrying transparencies.

Figures 15 and 16 are respectively a view in front elevation and from the left of a multiple plate system with rolling and pitching simulation.

Figure 17 is a vertical section of the simulation room.

On a navigation bridge placed at the centre of a cylindrical screen, the manoeuvring control desk for the bearing ship N has a helm B and a control for the speed S (speed selector for example), shown in Fig. 4. In the same room, or in a supply room, there are placed a helm $B1$ and a speed selector $S1$ for the in-sight ship. There may be several in-sight movable devices whose manoeuvring controls are represented by $B2$, $S2$ etc. To facilitate explanation, first there will be considered only the manoeuvres of the first in-sight ship $N1$, in relation to moving ship N. Controls B, S and $B1$, $S1$ act on computers whose pairing provides a supply computer 1 with two necessary items of information: co-ordinates x and y of ship $N1$ with regard to orthogonal axes OX and OY (OY being on the true North-South line), whose origin O is placed on the bearing ship N, as shown in Figure 1.

In Fig. 1, X_0 and Y_0 are the coordinate distances of the centre of the ship N with respect to the general reference axes and X and Y are the respective coordinate distances of the centre of the ship N, with respect to the centre of the ship N.

Reference is made later herein to these computers which continuously give co-ordinates of N, on its apparent relative trajectory Ta in relation to axes OX, OY (and thus in relation to ship N).

For easier understanding of the invention, the values x and y are given in terms of angular adjustment of two shafts. It is easy to substitute for them electrical quantities such as variable voltages.

The supply computer 1 changes values x and y into polar co-ordinates θ and ρ according to an already known process (see Fig. 1 and 2). The angular variation θ is conveyed onto shaft 2. The distance NN', that is to say ρ, is measured by a voltage which is amplified and conveyed to its destination by connection 3.

The shaft 2 drives a differential system 4 in which the shaft rotates correspondingly with the true course Cv of the ship N. It will be understood that the shaft 6 adjusts angularly according to the bearing $Gi=\theta-Cv$; shaft 7 driven by shaft 2 drives a differential 8 which receives, through its shaft 9, the angular indication of the true course $Cv1$, provided by the elementary computer of ship $N1$. Then shaft 10 rotates by a value $Cv1-\theta$, equal to $I1$ (the inclination of ship $N1$ for the observer standing at ship N, as shown in Fig. 2). The information provided by connection 3 (ρ) and shafts 6 and 10, is conveyed electrically to three slave motors 17, 21 and 22 controlling the movements of rotation of the main gears of each in-sight ship projection device. Differentials 4 and 8 may be replaced by electronic devices computing ($\theta-Cv$) or ($Cv1-\theta$).

A projector 11 with a variable focal length projects transparencies 12 through its total reflection prism 13, onto the cylindrical screen 14. The diameter of the screen 14 is about 20 metres. The light beam from prism 13 may go up and down but it is always directed in the same vertical plane passing through the axis WW' of the cylindrical screen. The entire projector may rotate around this axis. Its variable focal length control 15 allows an enlargement from 1 to 20 times, for example. An image 16 which has a diameter of 0.12 m. may, in this case, be enlarged to 2.40 m. According to this example, a ship 150 metres long may be seen from distances varying from 12,500 to 625 metres with a cylindrical screen of 90° to 270° inclination and having a diameter of 20 metres.

The motor 17 driven by the supply computer in terms of distance $NN1-\rho$ regulates the focal length from the control 15. At any moment, the apparent diameter of image 16 is then that of ship $N1$ seen in reality at the variable distance ρ.

The mounting for the transparencies 12 may be made according to several variants. In a first case, a horizontal disc 18 rotates around its axis 19 carried by a plate 20. which also carries projector 11, which plate 20 rotates around the central axis WW' (see

Fig. 4) of the screen. On the periphery of the disc (Figs. 6 and 7), there is a large number of transparencies 12, for example 180. They represent ship $N1$ seen by an observer standing on the bridge of ship N, for inclinations $I1$ varying successively by e° on a complete rotation (equal to 2° for 180 transparencies) by rotating clockwise from the positive part of the pole beam ρ. These transparencies are obtained by successive photos by rotating in steps of e° around ship $N1$ or a model of the latter. The model may also be placed on a dividing plate, for the previous taking of photos.

Referring to Figs. 2 and 4, it is then possible immediately to represent ship $N1$ (in a position defined by θ and ρ) by a projection operation, such as would be seen by the pilot of ship N, by making the following operations: plate 20 is orientated around WW′ according to bearing Gi with regard to ship N; then the disc 18 is rotated until the transparency, corresponding to inclination I, is in the projector 11; then the focal length of control 15 is adjusted corresponding to ρ. I designates the azimuth angle of a ship. The first operation is made by motor 21, the second one by motor 22, and third one by motor 17, the three motors being driven from the supply computer 1 according to the above explanations summed up in Fig. 4.

Disc 18 is rotated by its motor 22, not continuously but according to a principle similar to that of cinematography. When each of the successive transparencies presents itself in the projector it stops for a period which is related to the speed of rotation of the disc. It is obscured when it moves. Thus, if the disc rotates from e° round to e°, the observer on ship N will have the impression that the in-sight ship $N1$ has turned on itself. It makes a complete turn in the same time as the disc. One method of construction is shown in Figs. 6, 10 and 11. The cog-wheel 23 driven by motor 22 carries a contact 24 (electrically fed resilient finger). On a level with this finger 24, two metallic half-crowns 25 and 25*a* mounted on the disc-rack 26 are spaced by a distance corresponding to the angular displacing e° of two successive transparencies. When finger 24 touches one of the half-crowns 25 and 25*a*, the contact sets in operation one or the other of the ratchet systems 27 or 28, which quickly rotates the disc by an angle of e° at each impulse. The quick advance of system 27 (or 28) closes the shutter 29 above the in-position transparency. The next impulse will occur only if contact 24 is again on one of the half crowns 25 or 25*a*. The position of the transparencies may be ensured by notching and a spring pawl. The disc 18 is tightened by a disc 30 and a nut 31. The simulator is provided with several transparent discs 18 corresponding to a wide variety of real ships. They may be reproduced as photographic proofs from an original negative disc. According to a variant (Fig. 8), the disc 18*a* at least possesses two or more rows of transparencies 12*a* and 12*b*. After a turn, there is a relative movement of the projector and of the disc in order to operate the second row of transparencies (the complete turn of the ship is made on two disc turns). Motor 22 is enslaved consequently. Another row of transparencies may provide projection of the ship seen at night.

The complete reflection prism 13 of the projector may rotate around a horizontal axle 32, correcting the site angle. As shown in Fig. 9, a cam 33 synchronized with the slave motor 17 (focal distance) acts on a lever 34 and suitably corrects the image height on the screen in accordance with the effect of approaching or withdrawing of the ship. The angular distance α under which the water-line of ship $N1$ and the sky-line are seen varies with ρ.

According to a second method of construction of the device (Figs. 12 to 14) successive transparencies 12 may be set out over a belt 35 in two rectilinear rows 36 and 37 each comprising F photos, the first of which (12*c* and 12*d*), and the last of which (12*e* and 12*f*) are precisely side by side. If 12*c* represents ship $N1$ seen from the rear (inclination $I1=0°$), transparencies of the row 36 will show it progressively rotating on itself and exposing its starboard side, until the last transparency 12*e* which shows it seen ahead ($I1=180°$). From 12*f* to 12*d*, the photos show the ship manoeuvring successively from 180° to 360° inclination (progressive exposure of its port side). When the ship effects a turn on itself, transparencies pass successively along the path (Fig. 14), from 12*c* to 12*f*, between the projector 11*a* and the variable focal distance lens 15 with a motor 17 enslaved to ρ values, set out horizontally. The path between the two rows 36 and 37 is carried out either by an automatic translation movement of the belt 35, that is to say of the reels 38 and 39 on which the flexible belt winds up or unwinds, or by a vertical movement of the projector-lens set. The device for successive advancement of transparencies on a row is made by notched rollers 40 and 41 rotated by impulses caused by the motor 22 enslaved to $I1$ inclination values. The intermittent drive may be identical with the previously described contact finger 24 and crowns 25 and 25*a*. It may also be formed with gears as used in cinematography, with an occultation shutter, not shown on the drawings. The number of transparencies may be greater than that which is present on a disc 18 to improve the fineness of movement. The assembly is mounted on a plate 42 bearing on the plate 20 and may pivot about the hinges 43, to correct the angle α between

the sky-line and the water-line of the ship. As previously, the motor 17 drives a correcting cam 33*a*. According to a third method for making the device, the belt 35 possesses only a single row of transparencies, and is looped into an endless film. A second projection system 44 (seen in broken lines) may duplicate the first one. It possesses transparencies showing a larger scale ship, in order to provide the possibility of simulating the approach to a few tens of metres.

It is simple to project photos of islets (Fig. 3) or stationary floating devices, because the latter do not move ($Cv1=0$ and $I1=-\theta$). Several projectors on a single plate 20 may embody a continuous succession of coastlines.

On a column 45 there may be mounted several plates corresponding to several ships *N*, *N2*, etc. or several islets or portions of coastlines, as shown in Figs. 15 and 16. In the upper part of the column, a joint with a crown 46 and cross-piece 47 constitutes a universal joint. The base of the column is moved in two alternative movements, one on the axis of the bridge, the other in a perpendicular direction, simulating rolling and pitching. Two variable-speed and non-reversible rotating direction slave motors 48 and 49 answer to a predetermined programme. The projection set is then moved in two rocking movements, and the upper cross-piece 47 may carry a device for projecting sky-line, and possibly also clouds.

There are as many supply computers 1, with differentials 4 and 8, as there are plates 20. When two ships *N1* and *N2* are on the same bearing, the farthest ship automatically vanishes. A common device for reading electrical characteristics, measuring at connection 3 and shaft 6 the bearings (Gi) and pole beams (ρ), and compares these different values and causes either the striking out of the farthest device image, or the reinforcing of the light strength of the nearest one (in the case of a ship in front of a coast).

The relative co-ordinates x and y of each in-sight ship are obtained by an analogue or numerical or mechanical computers able to combine one with another. Fig. 4 (lower part) gives, as an example, a sketch of the manner of connection of electro-mechanical computers. Reference numeral 5 indicates the mechanical coupling coordinating the respective angular positions of the ships *N* and *N1* and the computers 50 and 53. Connection between coupling 5 and computer 53 is obtained by differential 4, shaft 2 and differential 8. The computer 50 controlled by the helm *B* and coupling 5 gives at its output shafts 51 and 52 the instantaneous co-ordinates of the bearing ship *N* on the surface. It also gives at each moment the value of the angular speed of true course *Cv* variation (coupling 5). The computer 53, which is identical with the first one, with helm *B1* and speed selector *Cv1* gives, at 54 and 55, the same indications relative to the first in-sight ship *N1*. The same holds true for the second ship *N2* etc. The computer 56, simulating the sea current conditions in the region of the ship *N*, provides corrections of the instantaneous co-ordinates, with regard to the sea bottom, of the bearing ship and in-sight ships.

It is easy to prove x to be equal to the difference between the abscissae obtained in this way, because y is the difference between the corresponding ordinates. In Fig. 4 these results are obtained by differentials 57 to 60, by supposing that the abscissae and ordinates are expressed as angles of rotation of the shafts 51, 52, 54, 55 etc. Coupled to the computer 50, two cams 61 and 62 alter the true course (that is, the trajectory of ship *N*) and ship's speed in terms of wind direction v and of true course *Cv*. The cams 63 and 64 alter the same elements in terms of waves and true course direction *T*.

The computers of the bearing ship and in-sight ships, which, in particular, determine at each moment the angular speed of true course *Cv* variation, taken in account the rotating effect of the propellers. They also take in account the inertia of the various gears, on changing gear. The co-ordinates of the ship *N* and in-sight ships *N1*, *N2* may control one or several x—y plane tables 65.

The simulation room is shown in Fig. 17. A hemispherical cupola 66 simulates the sky. The head and stern of the ship are projected on the screen 14 or represented by models.

WHAT I CLAIM IS:—

1. A device, for simulating navigation comprising:

a) a cylindrical screen for projecting images thereon, said images simulating the position of observed objects relative to an observer,

b) a rotatable support plate,

c) a plurality of image means connected to said support plate and rotatable therewith,

d) image projecting means mounted on said support plate and rotatable therewith, said image projecting means comprising:

i) a light source connected to said support plate,

ii) an adjustable focal length objective lens positioned for alignment with said light source, said objective lens supported by said support plate.

e) means for rotating said support plate for projecting images at various angles about the rotation axis of said rotatable support plate,

f) means for adjusting the magnification of said focal length objective lens thereby providing projected images of a variable size, and

g) means for successively positioning different ones of said plurality of image means for projection by said aligned light source and objective lens, whereby different projected images may be displayed simulating different orientations of the observed object relative to the observer.

2. A device, as claimed in claim 1 further comprising:

a) input means for varying

i) the bearing of the projected image,
ii) the size of the projected image,
iii) the orientation of the projected image.

b) means connected to said variable bearing input means for controlling the rotational position of said support plate,
c) means connected to said variable size input means for controlling the magnification adjusting means of said objective lens, and
d) means connected to said variable orientation input means for controlling the positioning means.

3. A device, as claimed in claim 1, wherein said light source is positioned on one side of said image means and said objective lens is positioned on the other side of said image means.

4. A device, as claimed in claim 1, further comprising, means for tilting the rotation axis of said rotatable support plate thereby projecting tilted images simulating rolling and pitching of objects.

5. A device, as claimed in claim 1, wherein said support plate is horizontal and rotatable about a vertical axis, said objective lens and said light source are aligned in a vertical direction and said apparatus further comprises a prism for reflecting said images in a generally horizontal direction.

6. A device, as claimed in claim 5, including means for rotating said prism about a horizontal axis.

7. A device, as claimed in claim 1, wherein said support plate is horizontal and rotatable about a vertical axis and said objective lens and light source are aligned in a horizontal direction.

8. A device, as claimed in claim 1, further comprising a plurality of support plates, each plate having a plurality of image means and associated light source and objective lens, said support plates rotatable about a common rotation axis.

9. A device, as claimed in claim 1, wherein said image means comprises:

a) a rotatable disc,
b) a plurality of transparent slide means disposed on the periphery of said disc,
c) said positioning means comprising motor means for rotating said rotatable disc.

10. A device, as claimed in claim 1, wherein said image means comprises:

a) a pair of spaced bobbins,
b) a band wound on said bobbins,
c) a first plurality of transparent slide means mounted in a first row on said band,
d) a second plurality of transparent slide means mounted in a second row on said band, and
e) means for rotating said bobbins to position various ones of said transparent slide means between said light source and said objective lens for projection onto said screen, whereby various orientations of said images are displayed simulating various orientations of said observed object.

11. A device, as claimed in claim 10, wherein said image means further comprises an endless loop-like band having transparent slides mounted thereon.

12. A device, as claimed in claim 1, wherein said cylindrical screen extends substantially 360° about said projecting means.

13. A device, for simulating navigation, substantially as described herein with reference to the accompanying drawings.

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FIG. 1

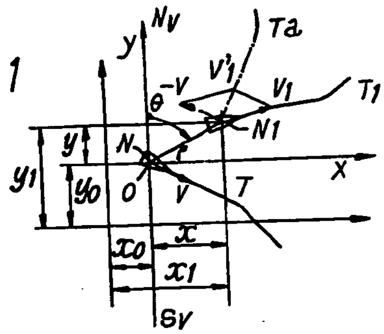


FIG. 2

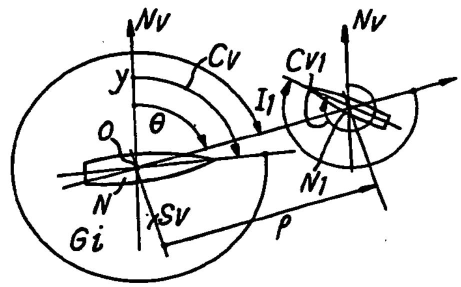


FIG. 5

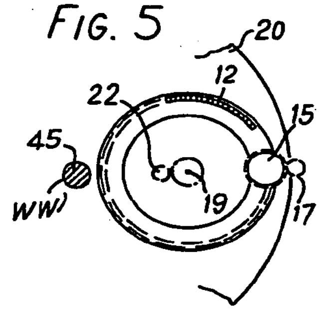


FIG. 3

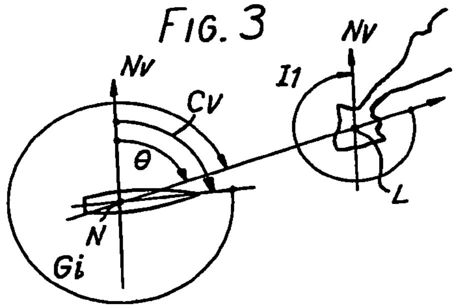
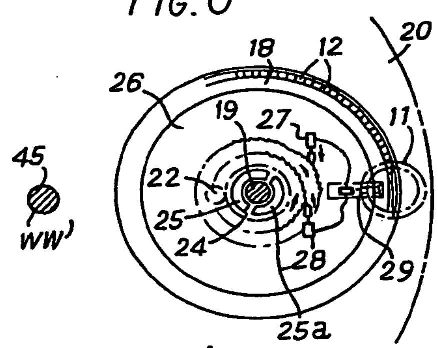


FIG. 6



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4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

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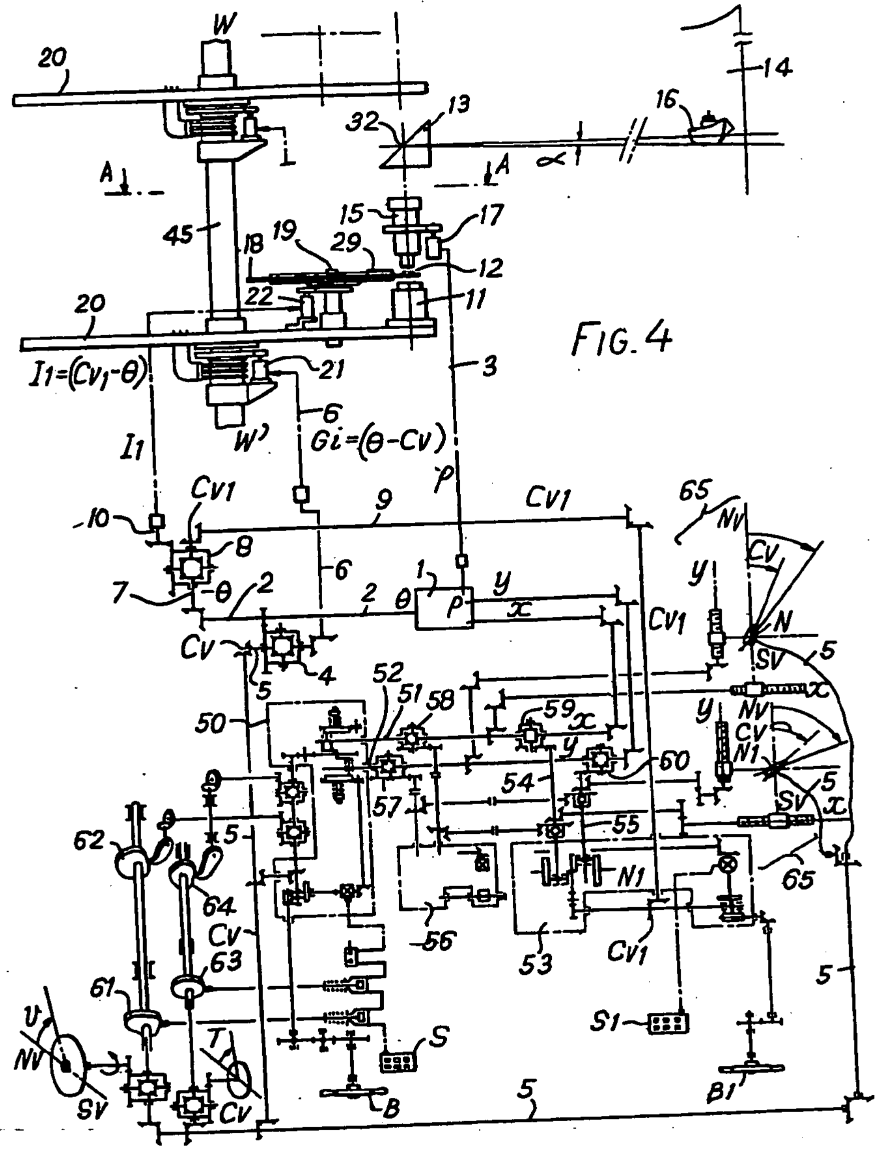


FIG. 4

FIG. 7

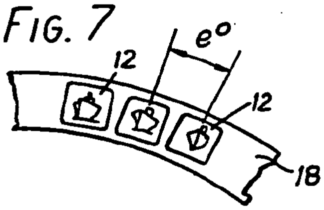


FIG. 8

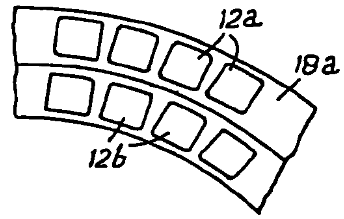


FIG. 9

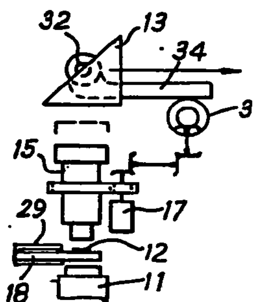


FIG. 10

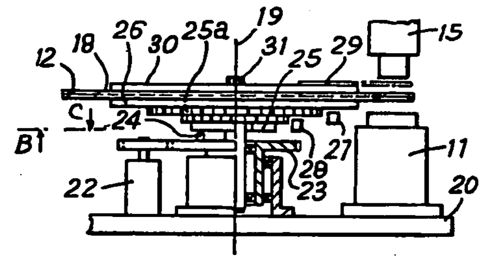


FIG. 11

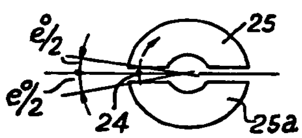


FIG. 12

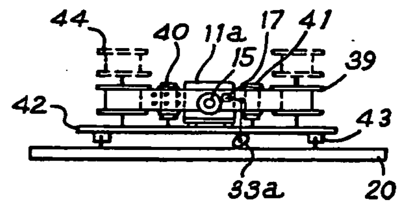


FIG. 13

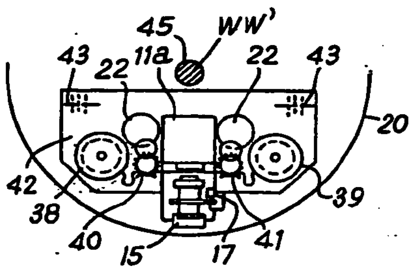
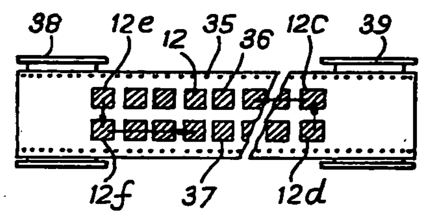


FIG. 14



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Sheet 4

FIG.15

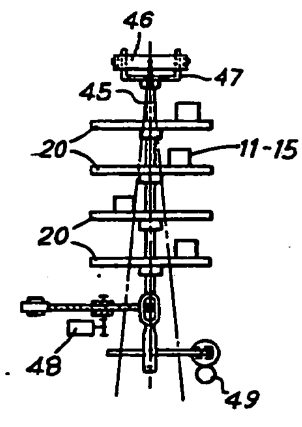

FIG.16

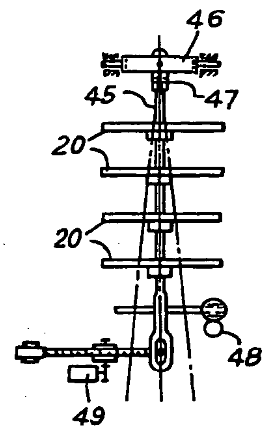

FIG.17